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Bohan et al.

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(54) **WARM WEATHER BOILER SHUTDOWN**

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(51) **Int. Cl.**

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F24D 3/00	(2006.01)
G05D 23/19	(2006.01)
F24D 11/00	(2006.01)

(52) **U.S. Cl.**

CPC ***F24D 3/00*** (2013.01); ***F24D 19/10*** (2013.01); ***F24D 19/1009*** (2013.01); ***G05D 23/1919*** (2013.01); *F24D 11/004* (2013.01)

(58) **Field of Classification Search**

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USPC ..... 237/8 A, 8 B, 12, 2 A, 59, 81; 122/14.21
IPC F24D 3/00, 11/00, 19/10
See application file for complete search history.

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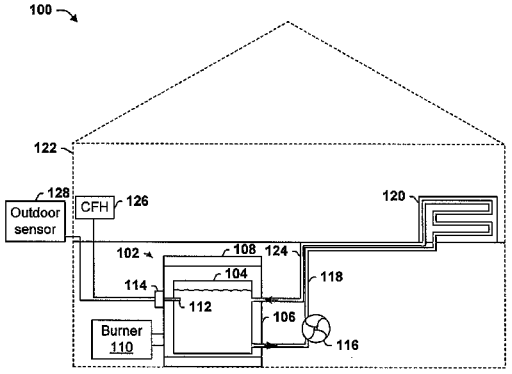
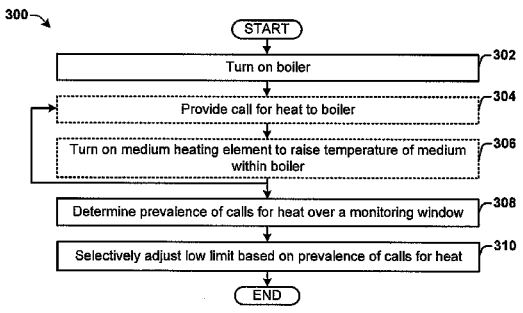
(57) **ABSTRACT**

The present disclosure relates to an apparatus for automatically shutting down a boiler system when it is not needed (e.g., during warm weather) based upon calls for heat output by a temperature control element (e.g., thermostat) within a facility. The apparatus has a temperature control element that provides calls for heat to a controller when a temperature within a facility is below a setting value. The controller controls operation of a boiler, having a medium with a temperature between a low limit and a high limit, in response to the call for heat. A monitoring element determines a prevalence of calls for heat and selectively adjusts the low limit based upon the determined prevalence of calls for heat. Therefore, when calls for heat are less frequent the monitoring element will reduce the low limit to reduce fuel consumption of the boiler.

20 Claims, 6 Drawing Sheets





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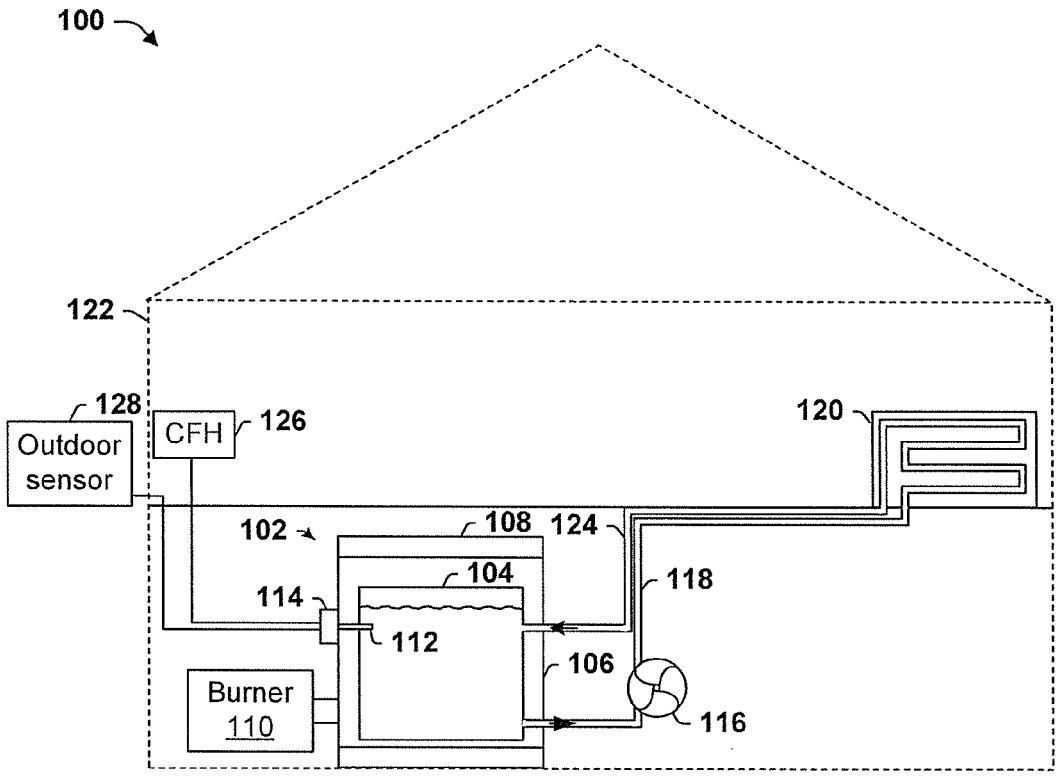
100
122
128
Outdoor sensor
CFH
126
120
102
108
124
104
118
114
112
106
Burner 110
116

Fig. 1

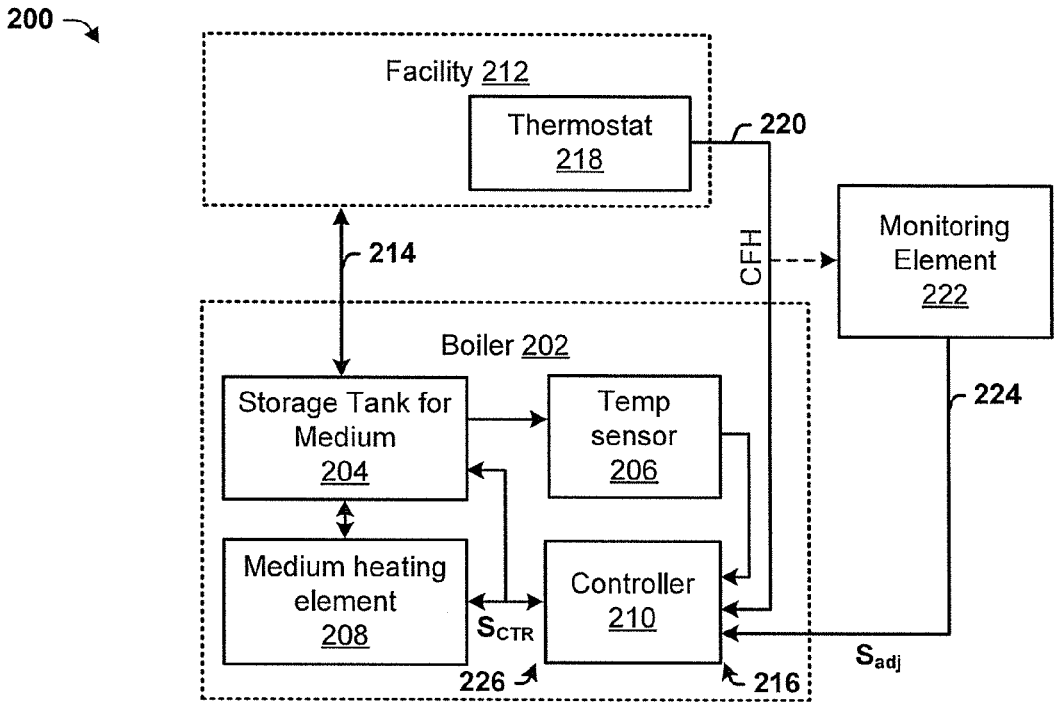
200
Facility 212
Thermostat 218
220
214
CFH
Monitoring Element 222
Boiler 202
224
Storage Tank for Medium 204
Temp sensor 206
Medium heating element 208
Controller 210
S_{CTR}
S_{adj}
226
216

Fig. 2

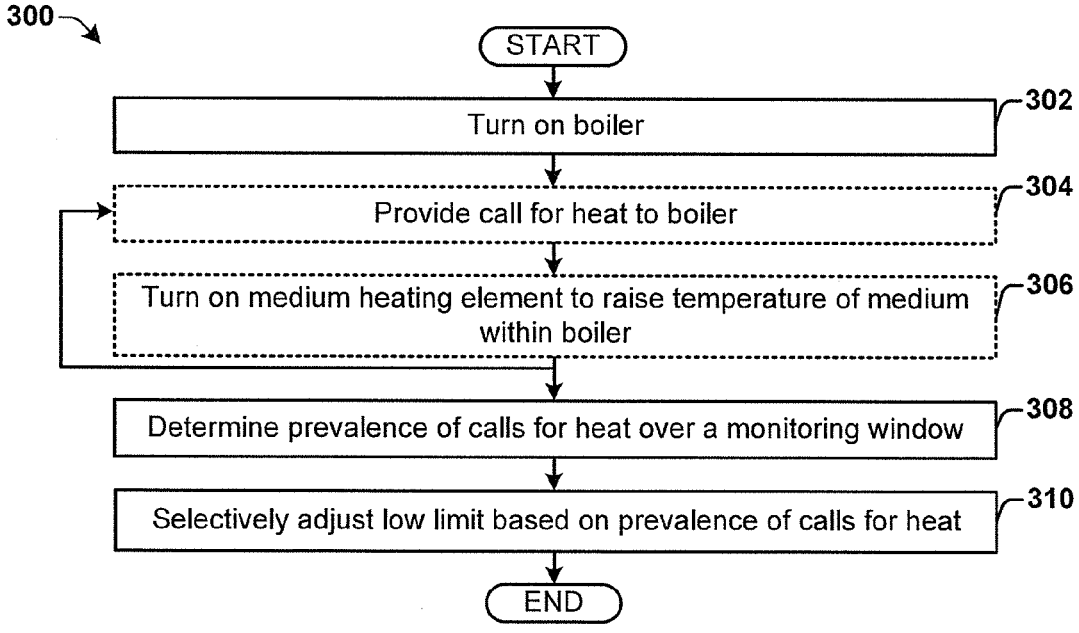
300
START
Turn on boiler
302
Provide call for heat to boiler
304
Turn on medium heating element to raise temperature of medium within boiler
306
Determine prevalence of calls for heat over a monitoring window
308
Selectively adjust low limit based on prevalence of calls for heat
310
END

Fig. 3

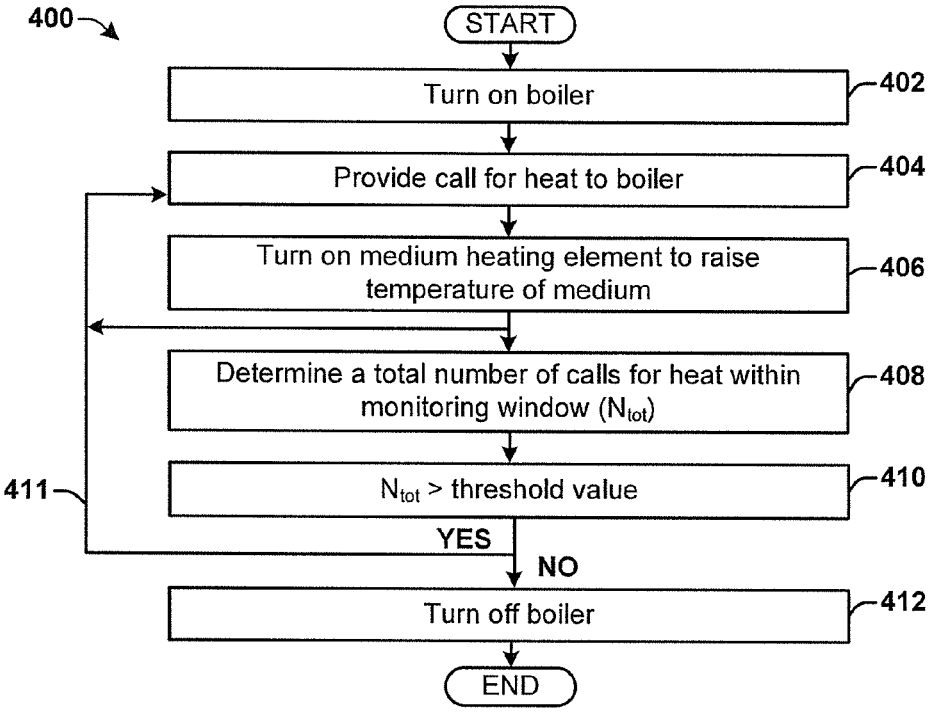
400
START
Turn on boiler
402
Provide call for heat to boiler
404
Turn on medium heating element to raise temperature of medium
406
Determine a total number of calls for heat within monitoring window (N_{tot})
408
N_{tot} > threshold value
410
411
YES
NO
Turn off boiler
412
END

Fig. 4A

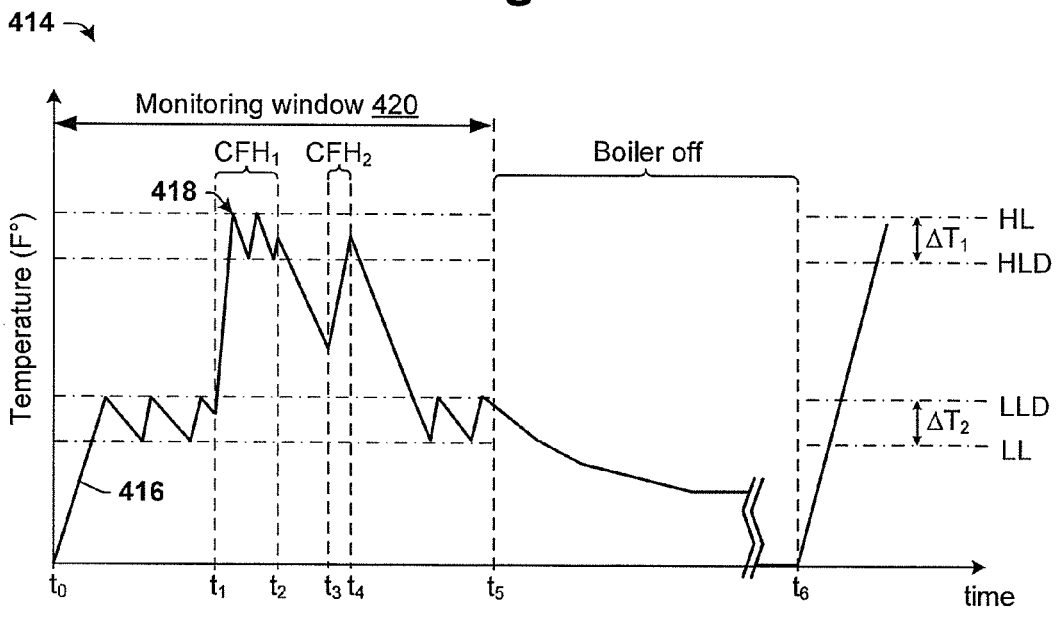
414
Monitoring window 420
CFH_1
CFH_2
Boiler off
418
HL
HLD
ΔT_1
LLD
LL
ΔT_2
416
Temperature (F°)
t_0
t_1
t_2
t_3
t_4
t_5
t_6
time

Fig. 4B

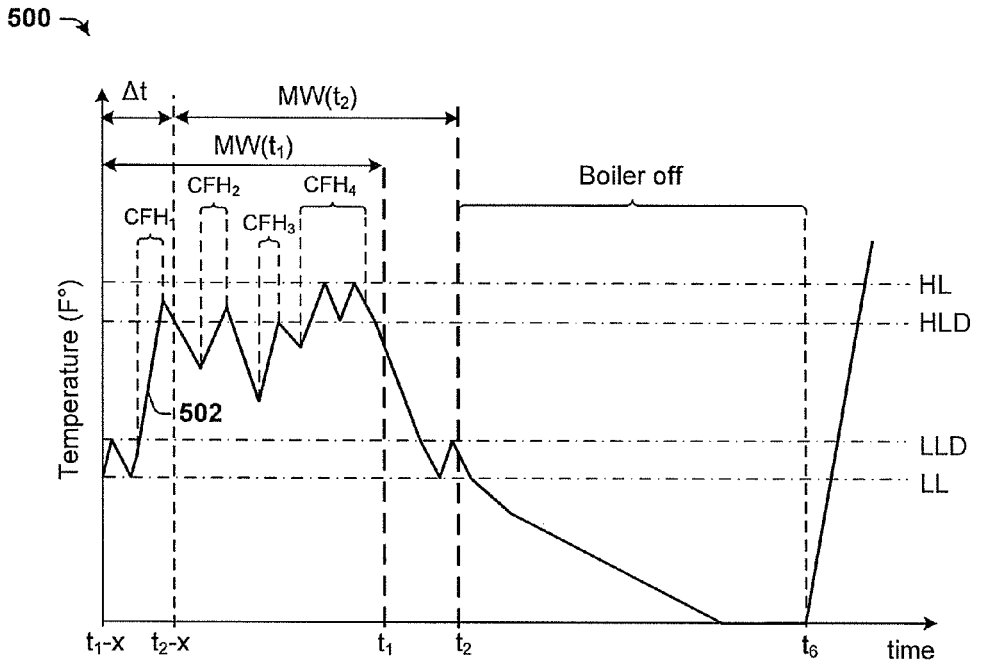
500
Δt
MW(t2)
MW(t1)
CFH1
CFH2
CFH3
CFH4
Boiler off
HL
HLD
LLD
LL
502
Temperature (F°)
t1-x
t2-x
t1
t2
t6
time

Fig. 5

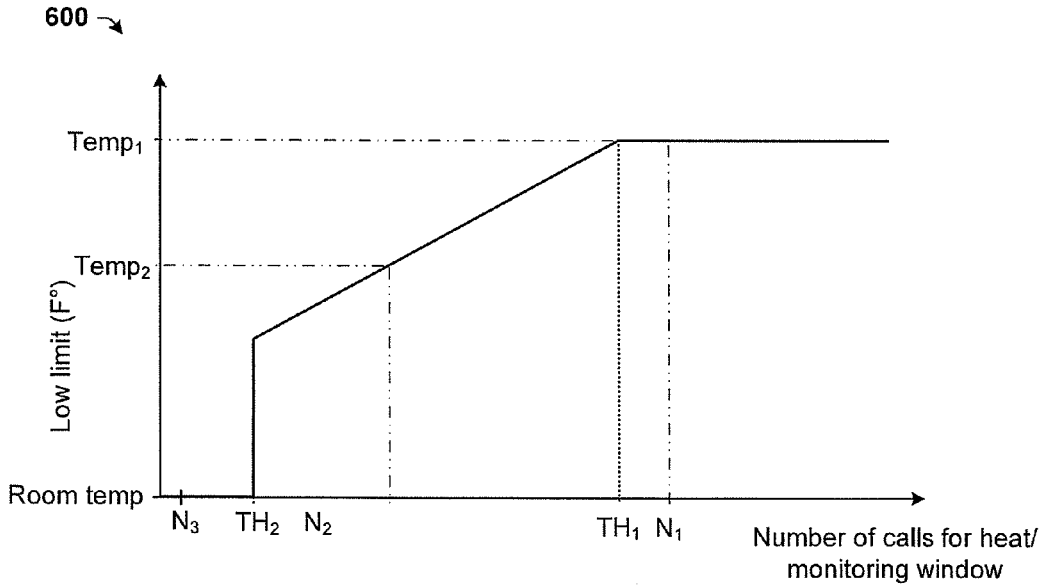
600
Temp1
Temp2
Low limit (F°)
Room temp
N3
TH2
N2
TH1
N1
Number of calls for heat/
monitoring window

Fig. 6

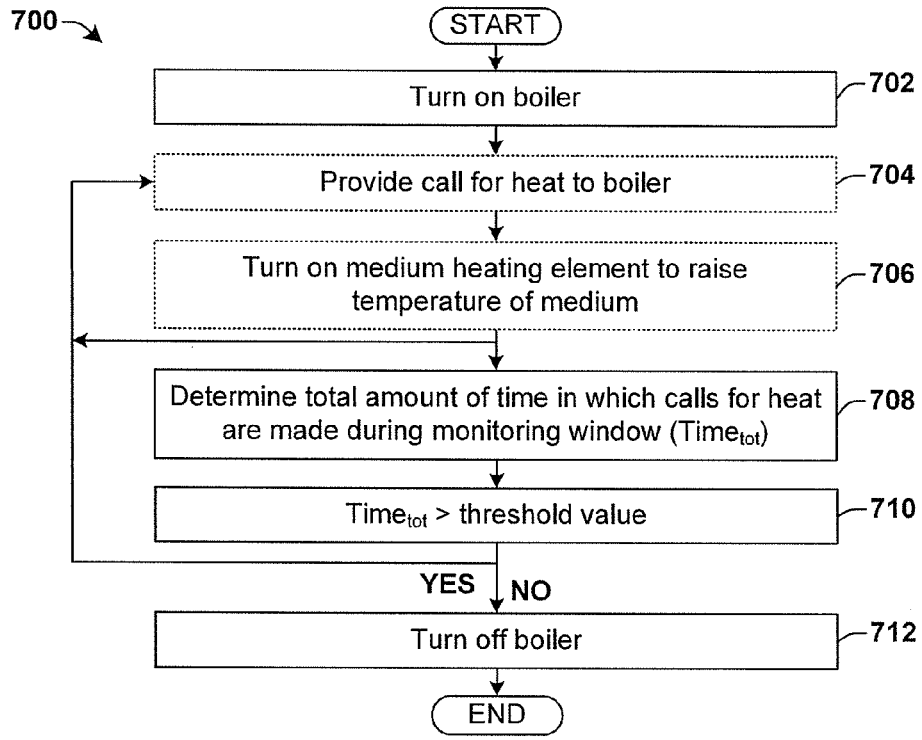
700
START
Turn on boiler
702
Provide call for heat to boiler
704
Turn on medium heating element to raise temperature of medium
706
Determine total amount of time in which calls for heat are made during monitoring window ($Time_{tot}$)
708
$Time_{tot}$ > threshold value
710
YES
NO
Turn off boiler
712
END

Fig. 7A

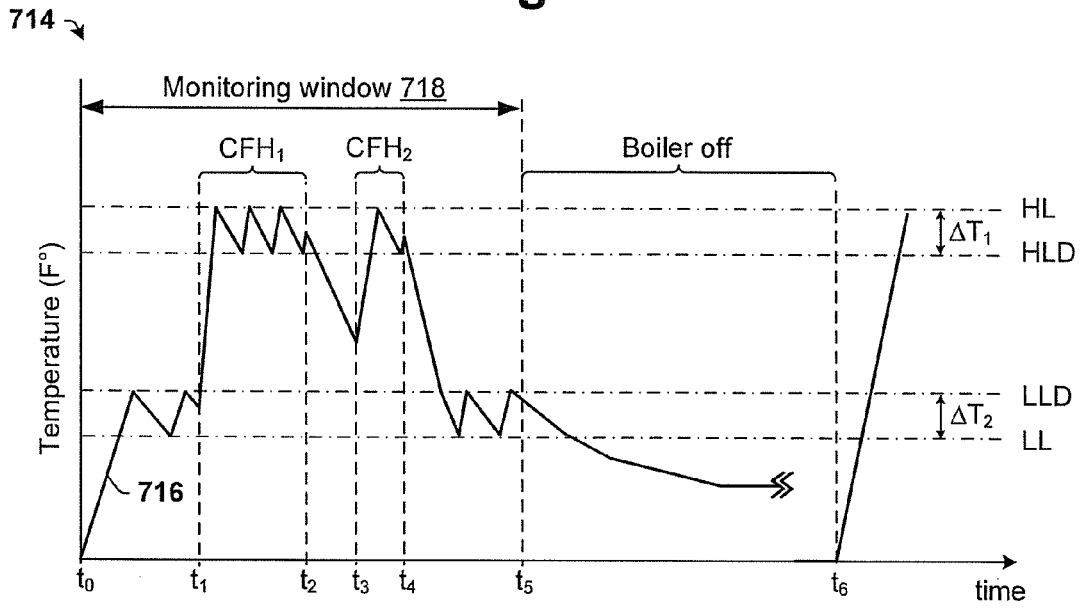
714
Monitoring window 718
CFH_1
CFH_2
Boiler off
HL
HLD
LLD
LL
ΔT_1
ΔT_2
Temperature (F°)
716
t_0
t_1
t_2
t_3
t_4
t_5
t_6
time

Fig. 7B

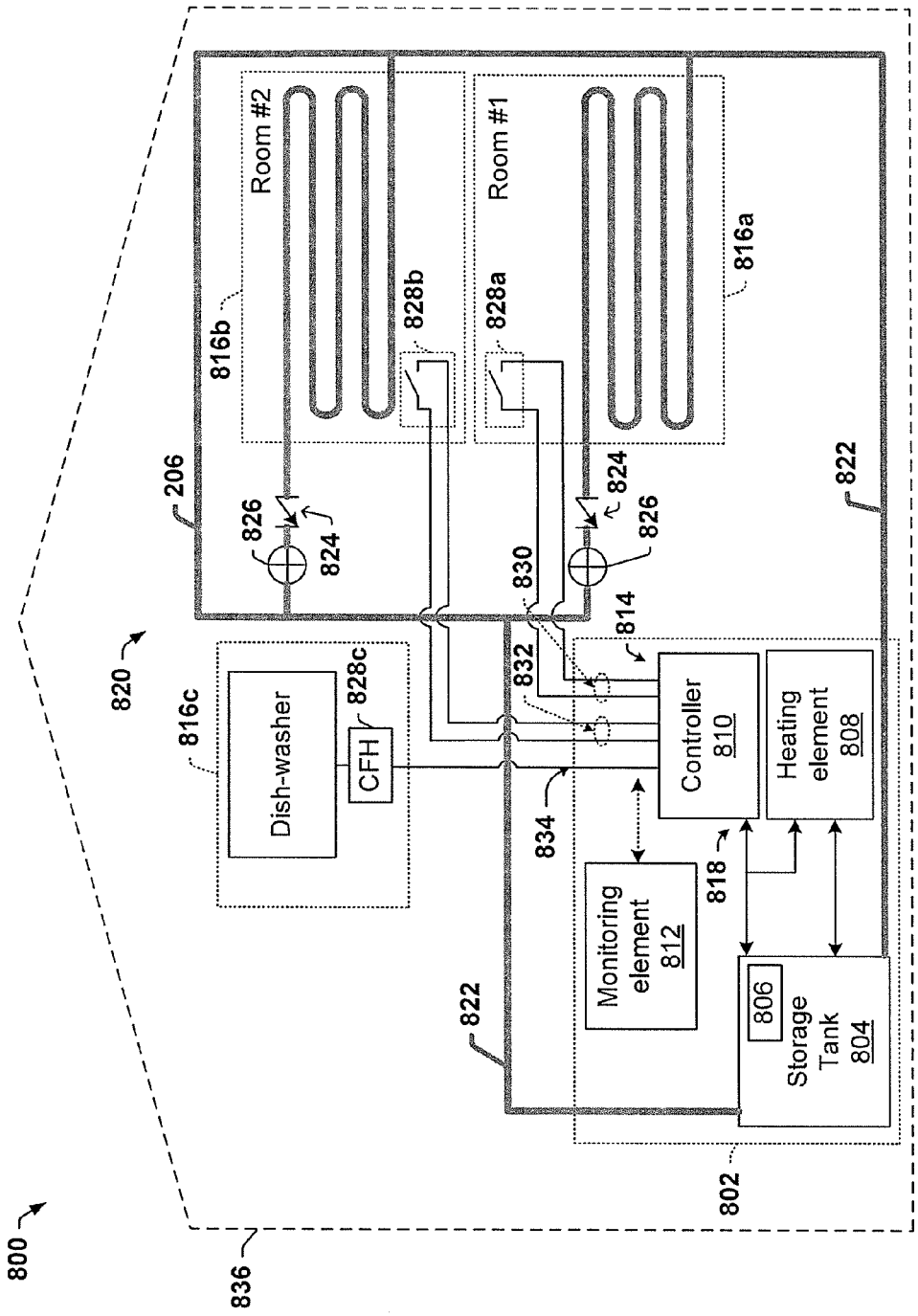
800
836
820
206
816b
Room #2
828b
Room #1
828a
816a
826
824
824
826
830
814
832
822
816c
Dish-washer
828c
CFH
Controller
810
Heating
element
808
834
818
Monitoring
element
812
806
Storage
Tank
804
822
802

Fig. 8

WARM WEATHER BOILER SHUTDOWN

BACKGROUND

Boiler systems have been used to regulate the temperature of commercial and residential facilities for a number of years. However, despite the fact that boiler systems have been around for many years, innovations continue to change the manner in which these systems operate.

Conventional boiler controllers are often configured to constrain a temperature of a medium (e.g., water) comprised within a boiler (or other type heating appliance) between a low limit (LL) and a high limit (HL). The high limit (HL) is employed to prevent the medium temperature from exceeding some predetermined level to avoid a situation where a medium having an undesirably high temperature reaches a recipient. The low limit (LL) is typically set by a technician or as a default value to maintain the medium at some minimum level.

The low limit (LL) is important in extending the life and improving the safety of boilers. For example, excessive cold boiler starts may cause the boiler block to crack due to the thermal shock of starting a cold boiler. Furthermore, cold boiler water causes condensation of combustion flue products, which can accelerate corrosion of vent systems and heat exchangers. If the corrosion causes a breach of the vent system, combustion products may enter the home and pose a health hazard to its occupants.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram of conventional boiler system having an outdoor sensor configured to enable a warm weather shutdown procedure.

FIG. **2** is block diagram of a disclosed boiler system having a monitoring element configured to selectively adjust the low limit of a boiler system controller based upon detected calls for heat.

FIG. **3** is a flow diagram showing some embodiments of a method for reducing a controller low limit (LL) based upon a prevalence of calls for heat.

FIG. **4**A is a flow diagram showing some embodiments of a method for executing a warm weather shutdown procedure based upon detected calls for heat.

FIG. **4**B is a timing diagram of medium temperature of a boiler system operated according to the method of FIG. **4**A.

FIG. **5** is timing diagram illustrating how a monitoring widow changes in a boiler system executing a warm weather shutdown procedure of a boiler based upon detected calls for heat.

FIG. **6** illustrates a graph showing the dynamic adjustment of a low limit based upon a total number of calls for heat within a monitoring window.

FIG. **7**A is a flow diagram showing some alternative embodiments of a method for executing a warm weather shutdown procedure based upon detected calls for heat.

FIG. **7**B is a timing diagram of medium temperature of a boiler system operated according to the method of FIG. **7**A.

FIG. **8** is a block diagram of a boiler system comprising a plurality of zones, respectively configured to send calls for heat to a boiler.

DETAILED DESCRIPTION

The present disclosure will now be described with reference to the drawings where like reference numerals are used to refer to like elements throughout, and where the illustrated structures are not necessarily drawn to scale. Nothing in this detailed description is admitted as prior art.

FIG. **1** illustrates a conventional boiler system **100** having an outdoor temperature sensor **128** configured to enable a warm weather shutdown procedure. The boiler system **100** includes a boiler **102** comprising a storage tank **104** surrounded by an insulating material layer **106**, which is encased within a boiler enclosure **108**. A medium heating element **110** works in conjunction with a temperature sensor **112** directed by a boiler controller **114** to heat a medium within the storage tank **104** to a desired temperature. After the medium is heated to the desired temperature, a circulation pump **116** pumps the heated medium by way of an outbound line **118** to a radiating element **120**, which radiates heat within a residential or commercial facility **122**. The heated medium returns from the radiating element **120** through a return line **124** to the storage tank **104**.

The boiler controller **114** is connected to a temperature control element **126** located within the facility **122** and an outdoor temperature sensor **128** located outside of the facility **122**. The temperature control element **126** is configured to provide a call for heat to the controller **114** when a temperature within the facility **122** falls below a setting value of the temperature control element **126**. The outdoor temperature sensor **128** is configured to detect a temperature outside of the facility **122** (i.e., an outdoor temperature) and to relay the detected outdoor temperature back to the controller **114**. If the outdoor temperature is above a certain level, the controller **114** determines that there is no need for the boiler **102** and turns it off.

While outdoor temperature sensors save fuel by not operating a boiler when it is not needed, such sensors require significant effort to install and can provide aberrant readings, for example, if physically located next to an external dryer vent, or when located in a sunny location.

Accordingly, the present invention relates to a method and apparatus for automatically shutting down a boiler system when it is not needed (e.g., during warm weather) based upon calls for heat output by a temperature control element (e.g., thermostat) within a facility. By enabling an automatic shutdown procedure based upon calls for heat output by a temperature control element, the problems faced by outdoor sensor systems are eliminated.

In some embodiments, the apparatus comprises a temperature control element configured to provide calls for heat to a controller when a temperature of a facility is below a setting value of the temperature control element. The controller controls operation of a boiler containing a medium having a temperature between a low limit and a high limit. During operation the controller increases the temperature of the medium in response to the calls for heat. A monitoring element is configured to determine a prevalence of the calls for heat and to selectively adjust the low limit based upon the determined prevalence of the calls for heat. Therefore, when calls for heat are less frequent the monitoring element will reduce the low limit to reduce fuel consumption of the boiler.

FIG. **2** illustrates a block diagram of a boiler system **200** comprising a monitoring element **222** configured to selectively adjust a low limit (LL) of the boiler system **200** (e.g., turn off the boiler system **200**) based upon the prevalence of the calls for heat during a temporal monitoring window.

As shown in FIG. **2**, the boiler system **200** comprises a boiler **202** having a storage tank **204** in which a medium (e.g., water or a water glycol mix) is stored, a temperature sensor **206** for detecting the temperature of the medium in the storage tank **204**, and a medium heating element **208** (e.g., gas burner, oil burner, or electric heater). The boiler **202** is con-

figured to exchange the medium with a facility **212** by way of a piping **214**, wherein a temperature of the facility **212** is regulated by heat radiated from the medium.

A controller **210** is operable to control operation of the boiler **202**. In some embodiments, the controller **210** comprises an input interface **216** connected to a temperature control element **218** (e.g., a thermostat) by way of a first communication channel **220**. The temperature control element **218** is configured to monitor a temperature within the facility **212** and to generate a call for heat (CFH) when the temperature within the facility **212** falls below a setting value of the temperature control element **218**. For example, if the temperature control element **218** is set to maintain a temperature of 70° within the facility **212**, it will generate a call for heat when a temperature within the facility **212** falls below 70°. The call for heat causes the controller **210** to generate a control signal S_{CTR}, provided at an output interface **226** of the controller, which causes the medium heating element **208** to operate to increase the temperature of the medium within the storage tank **204**. When the heated medium is provided to the facility **212**, it increases the temperature of the facility **212**.

The input interface **216** is further connected to a monitoring element **222** by way of second communication channel **224**. The monitoring element **222** is configured to detect calls for heat provided from the temperature control element **218** to the controller **210** and to determine a prevalence of the calls for heat. Based upon the prevalence of the calls for heat, the monitoring element **222** is configured to generate an adjustment signal S_{adj} that selectively provided to controller **210** to adjust the low limit (LL) of the controller **210**.

By monitoring the prevalence of calls for heat within a monitoring window (e.g., 1 day, 2 days, etc.), the monitoring element **222** can determine the extent to which the boiler **202** is being used to heat the facility **212**. For example, a low prevalence of calls for heat within a monitoring window indicate that the boiler **202** is rarely being used to heat the facility **212** and that the low limit (LL) of controller **210** can be reduced to reduce the fuel consumption of the boiler system **200**. Conversely, a high prevalence of calls for heat within a monitoring window indicates that the boiler **202** is being used often to heat the facility **212** and that the (LL) low limit of the controller **210** is not to be reduced.

In some embodiments, the monitoring element **222** determines a prevalence of calls for heat by detecting a total number of calls for heat over a monitoring window. If the total number of calls for heat is below a threshold value, the monitoring element **222** is configured to generate an adjustment signal S_{adj} that causes the controller **210** to reduce its low limit (LL). In some embodiments, if the total number of calls for heat is below the threshold value, the adjustment signal S_{adj} causes the controller **210** to execute a warm weather shutdown procedure that turns off the boiler **202** (i.e., setting the low limit equal to room temperature).

In other embodiments, the monitoring element **222** determines a prevalence of calls for heat by detecting a total amount of time in which call for heat are made over a monitoring window. For example, if 10 calls for heat, each lasting 8 minutes, are made over a monitoring window, the monitoring element **222** would detect a total amount of time in which calls for heat are made of 80 minutes. If the total time of calls for heat is below a threshold value, the monitoring element **222** is configured to generate an adjustment signal S_{adj} that causes the controller **210** to reduce its low limit (e.g., to execute a warm weather shutdown procedure that turns off the boiler **202**).

The monitoring element **222** may detect a call for heat in various ways. In some embodiments, the monitoring element **222** may detect calls for heat by monitoring the first communication channel **220** to directly detect a call for heat signal output by the temperature control element **218**. In other embodiments, the monitoring element **222** may detect calls for heat by indirectly detecting a quantity that indicates that a call for heat has been issued by the temperature control element **218**. For example, the monitoring element may detect a call for heat by detecting an increase in the temperature of the medium to a temperature above a low limit differential (See, FIG. **4**B).

It will be appreciated that the term 'communication channel' includes any medium of communication. For example, in some embodiments the first and second communication channels may comprise physical wires extending between elements, while in alternative embodiments the first and second communication channels may comprise wireless communication channels.

FIG. **3** is a flow diagram showing some embodiments of a method for reducing a controller low limit (LL) based upon a prevalence of calls for heat. While the exemplary method **300** is illustrated and described below as a series of acts or events, it will be appreciated that the present invention is not limited by the illustrated ordering of such acts or events. For example, some acts may occur in different orders and/or concurrently with other acts or events apart from those illustrated and/or described herein, in accordance with the invention. In addition, not all illustrated steps may be required to implement a methodology in accordance with the present invention.

At **302** a boiler is turned on. Turning on the boiler system causes the boiler system to increase the temperature of a medium within the boiler to at least a low limit (LL). Once the boiler is turned on, it will regulate the temperature of the medium between the low limit (LL) and a high limit (HL).

At **304** a call for heat may be provided to the boiler. A call for heat is received from a temperature control element (e.g., a thermostat) when the temperature control element determines that a temperature of an associated facility is below a setting value.

In response to the call for heat, a medium heating element within the boiler is activated at **306**. Activating the medium heating element raises the temperature of a medium that is held within the boiler. Steps **304** and **306** may be repeated multiple times over a time period (e.g., monitoring window) such that a plurality of calls for heat are provided to the boiler.

At **308** a prevalence of calls for heat is determined over a monitoring window. In some embodiments, the prevalence of calls for heat is determined by measuring a total number of calls for heat over the monitoring window. In other embodiments, the prevalence of calls for heat is determined by measuring a total time in which calls for heat are made over the monitoring window. The monitoring window comprises a time period (e.g., 12 hrs, 1 day, etc.).

At **310** the low limit is selectively adjusted based upon the prevalence of the calls for heat. In some embodiments, the low limit is reduced in proportion to the prevalence of calls for heat. In other embodiments, if the prevalence of calls for heat is below a threshold value, the boiler system is turned off, effectively setting the low limit to room temperature.

FIG. **4**A is a flow diagram showing some embodiments of a method **400** for executing a warm weather shutdown of a boiler system based upon detected calls for heat. FIG. **4**B illustrates a timing diagram **414** showing a medium temperature of a boiler system operated according to method **400**. It will be appreciated that although timing diagram **414** illustrates a boiler system that is configured to turn off if the

detected total number of calls for heat over a monitoring window is less than a threshold value of four (4), that any threshold value can be used.

At **402** the boiler is turned on. Turning on the boiler causes the boiler to increase the temperature of a medium within a storage tank until it reaches a low limit (e.g., 140° F.). The low limit comprises a minimum level that the temperature of the medium is not permitted to fall below.

For example, as shown in FIG. **4**B, at time t_0 the boiler is turned on. Upon turning on the boiler a medium heating element (e.g., boiler) is activated, causing the temperature of the medium **416** to steadily increase. Once the temperature of the medium **416** has reached the low limit (LL), a controller may operate to maintain the temperature of the medium **416** at a value that is between the low limit and a low limit differential (LLD), which exceeds the low limit (LL) by an amount ΔT_2. For example, when the temperature of the medium **416** falls below the low limit (LL) **202**, the medium heating element is activated despite no call for heat. The medium heating element remains on (via the controller) until the temperature of the medium **416** reaches the low level differential (LLD), at which time the controller instructs the medium heating element to turn off, allowing the temperature of the medium **416** to slowly decrease back toward the low limit (LL) **202**. The boiler will then cycle the medium heating element on and off to as shown.

At **404** a call for heat may be provided to the boiler.

In response to a call for heat, a medium heating element is operated to raise the temperature of a medium at **406**. The temperature of the medium will increase until either the call for heat is ended or the temperature of the medium has reached a high limit (HL) (e.g., 200° F.). Steps **404** and **406** may be repeated multiple times over a time period (e.g., monitoring window) such that a plurality of calls for heat are provided to the boiler.

For example, as shown in FIG. **4**B, at time t_1, a first call for heat (CFH_1) is received by a controller, and a medium heating element is turned on, causing the temperature of the medium **416** to steadily increase. Once the temperature of the medium **416** reaches the high limit (HL) at **418**, the medium heating element is deactivated by the controller to prevent the temperature of the medium **416** from exceeding the high limit (HL), thus resulting in a decrease in medium temperature despite the first call for heat (CFH_1) still being asserted. Once the temperature of the medium **416** falls below the high limit differential (HLD), the controller activates the medium heating element as long as the first call for heat (CFH_1) is still asserted. The control cycle between the high limit (HL) and the high limit differential (HLD) then continues until the first call for heat (CFH_1) time period ends at time t_2.

At a later time t_3, a second call for heat (CFH_2) is received by the controller and the medium heating element is turned on, causing the temperature of the medium **416** to steadily increase. The second call for heat (CFH_2) is finished at time t_4 and the controller turns off the medium heating element. The temperature of the medium **416** will decrease absent another call for heat until the temperature of the medium **416** falls below the low limit (LL).

At **408** a total number of calls for heat is determined over a monitoring window. As shown in FIG. **4**B, in a monitoring window **420** extending from time t_0 to a time t_5 two calls for heat (CFH_1 and CFH_2) are received.

At **410** the total number of calls for heat is compared to a threshold value. If the total number of calls for heat is greater than the threshold value, it indicates that the boiler is being used frequently and the boiler is kept on (arrow **411**). However, if the total number of calls for heat is less than the threshold value, it indicates that the boiler is not being used frequently and the boiler is turned off at **412** to reduce fuel costs.

As shown in FIG. **4**B, since the detected two calls for heat over monitoring window **420** are less than the threshold value of four (4), the controller turns off the boiler, allowing the temperature of the medium to be reduced to below the low limit (LL).

It will be appreciated that during operation of a boiler a monitoring window having a constant value will dynamically change its position in time. In particular, the monitoring window will extend backwards from a present time by a time value equal to the size of the monitoring window (i.e., the monitoring window will determine a prevalence of calls for heat over a monitoring window extending backwards in time from the present time).

FIG. **5** is timing diagram **500** illustrating how a monitoring widow changes in a boiler system executing a warm weather shutdown of a boiler based upon detected calls for heat. It will be appreciated that although timing diagram **500** illustrates a medium temperature for a boiler that is configured to turn off if the detected total number of calls for heat over a monitoring window is less than a threshold value of four (4), any threshold value can be used.

At a first time t_1, a monitoring window $MW(t_1)$ extends from a time t_1 to a time t_1-x, where x is the size of the monitoring window. During the duration of monitoring window $MW(t_1)$, the controller receives four calls for heat: CFH_1, CFH_2, CFH_3, and CFH_4. Since the total number of calls for heat, four, is equal to the threshold value of four, the controller keeps the boiler on and the temperature of the medium **502** is not allowed to go below the low limit (LL).

At a second time t_2, the position of the monitoring window $MW(t_2)$ has dynamically changed so that it extends from a time t_2 to a time t_2-x. During the duration of monitoring window $MW(t_2)$, the controller receives three calls for heat: CFH_2, CFH_3, and CFH_4. Since the total number of calls for heat, three, is less than the threshold value of four, the controller turns off the boiler and the temperature of the medium **502** is allowed to go below the low limit (LL).

It will be appreciated that in the disclosed boiler system, which is configured to selectively adjust the low limit of a boiler controller, the size of the monitoring window and threshold value has a direct correlation to operation of a boiler system. Accordingly, in some embodiments the monitoring element can dynamically vary the size of the monitoring window and threshold value to adjust operation of the boiler system. For example, the monitoring window and threshold value may be set to different values depending on the season (e.g., the monitoring window and threshold value may be set higher in the fall and spring than in the summer).

In particular, controlling the size of the monitoring window influences how quickly a boiler system is turned off (e.g., the size of the monitoring window is proportional to the time it will take for the boiler to turn off). For example, increasing the size of a monitoring window causes a boiler to turn off less quickly, resulting in less cold boiler starts. Alternatively, decreasing the size of a monitoring window causes a boiler to turn off more quickly, potentially saving fuel. In some embodiments, the size of a monitoring window is selected to have a size that minimizes the number of cold boiler starts due to weather changes.

Similarly, controlling the threshold value of calls for heat influences how often a boiler is turned off. Increasing the threshold value will cause the boiler to turn off more often. For example, a boiler system having a threshold value of one (1) will turn off if no calls for heat are made over a monitoring

window, while a boiler system using a threshold value of two (2) will turn off if zero or one calls for heat are made over the monitoring window. Alternatively, decreasing the threshold value will cause the boiler system to turn off less often (e.g., if the temperature within a facility is high at day and low overnight, the threshold value can be set to a number that does not turn off the boiler). For example, a boiler system having a threshold value of ten (10) will turn off if nine or less calls for heat are made over a monitoring window, while a boiler system having a threshold value of five (5) will turn off with five or less calls for heat over the monitoring window.

In some embodiments, the monitoring element is configured to dynamically adjust a low limit (LL) set by the controller based upon a prevalence of calls for heat. FIG. **6** illustrates a graph **600** showing the dynamic adjustment of a low limit based upon a total number of calls for heat within a monitoring window. The graph illustrates the low limit (LL) in degrees Fahrenheit on the y-axis and the total number of calls for heat per monitoring window on the x-axis.

As shown in graph **600**, as long as the total number of calls for heat over a monitoring window is greater than or equal to a first threshold value TH_1, the low limit (LL) is set equal to a first temperature value ($Temp_1$). However, if the total number of calls for heat decreases below a first threshold value TH_1, the low limit (LL) is dynamically reduced to a second temperature value ($Temp_2$), which is less than the first temperature value ($Temp_1$). For example, as shown in graph **600**, if the total number of calls for heat is a first number of calls for heat N_1 the low limit (LL) is set to $Temp_1$ (e.g., 140°). However, if the total number of calls for heat decreases to a second number of calls for heat ($N_2<N_1$) the low limit (LL) is set to $Temp_2$ (e.g., 120°). In some embodiments, if the total number of calls for heat decreases below a second threshold value (TH_2), the boiler is turned off, effectively setting the low limit (LL) equal to room temperature. For example, as shown in graph **600** if the total number of calls for heat decrease to $N_3<TH_2$, the boiler is turned off.

The goal of such a dynamic low limit is that when external temperatures are cold, the boiler system benefits from a higher low limit (LL) to meet the more demanding heating needs of a cold environment, while for warmer temperatures, a cooler average water temperature may still effectively meet the less stringent heating needs while consuming less fuel.

FIG. **7**A is a flow diagram showing some alternative embodiments of a method **700** for executing a warm weather shutdown procedure of a boiler based upon a total time in which calls for heat are made. FIG. **7**B is a timing diagram **714** of a medium temperature for a boiler system operated according to method **700**.

At **702** the method turns on a boiler configured to heat a medium. As shown in timing diagram **714**, at time t_0 the boiler system is turned on. Turning on the boiler causes the temperature of the medium **716** to increase until it reaches a low limit comprises a minimum level that the temperature of the medium is not permitted to fall below.

At **704** a call for heat may be provided to the boiler.

In response to a call for heat, a heating element is operated to raise a temperature of a medium at **706**. Steps **704** and **706** may be repeated multiple times over a time period (e.g., monitoring window) such that a plurality of calls for heat are provided to the boiler. For example, as shown in timing diagram **714**, at time t_1, a first call for heat (CFH_1) is received by a controller. The first call for heat (CFH_1) is asserted from time t_1 to time t_2. At time t_3 a second call for heat (CFH_2) is received by the controller. The second call for heat (CFH_2) is asserted from time t_3 to time t_4.

At **708** a total amount of time in which calls for heat are made is determined over a monitoring window. In timing diagram **714**, the total amount of time in which calls for heat are made is equal to $time_{tot}=(t_2-t_1)+(t_4-t_3)$.

At **710** the total amount of time in which calls for heat are made is compared to a threshold value. If the total amount of time in which calls for heat are made is greater than the threshold value, the boiler is kept on. However, if the total amount of time in which calls for heat are made is less than the threshold value, the method turns off the boiler at **712**.

As shown in FIG. **7**B, the total amount of time in which calls for heat are made over monitoring window **718** is less than the threshold value, causing the controller to turn off the boiler, allowing the temperature of the medium to be reduced to below the low limit (LL).

FIG. **8** shows an example of a boiler system **800** that delivers a heated medium to different zones of a residential or commercial facility **836**.

The boiler system **800** comprises a boiler **802** including a storage tank **804** in which the medium is stored, a temperature sensor **806** for detecting the temperature of the medium in the storage tank **804**, and a medium heating element **808** (e.g., gas burner, oil burner, or electric heater). In addition, the boiler **802** includes a controller **810** and a monitoring element **812**. The controller **810** includes an input interface **814** that is operable to receive calls for heat from multiple zones **816** (e.g., zones **816***a*-**816***c*), as well as an output interface **818** for delivering one or more control signals.

A medium delivery system **820** typically includes a series of pipes **822**, valves **824**, and circulators **826** positioned throughout the facility **836**. These components respond to various control signals to circulate the heated medium through the multiple zones **816** (e.g., zones **816***a*-**816***c*). The control signals for the medium delivery system **820** can stem from a controller **810** in the boiler **802** or from other controllers located elsewhere in the boiler system **800**.

The zones **816** can include respective temperature control elements **828** configured to provide calls for heat to controller **810**. In particular, first and second zones **816***a*, **816***b* are illustrated as first and second rooms having first and second temperature control elements **828***a*, **828***b*, respectively. The first and second temperature control elements **828***a*, **828***b* are shown as thermostats that each have a 2-wire connection coupled to first and second terminals **830**, **832** on the input interface **814** of the controller **810**. A third zone **816***c* is shown as a commercial dishwasher having a temperature control element **828***c*, which is shown as having a single line connection coupled to a third terminal **834** on the input interface **814** of the controller **810**. It will be appreciated that although specific interfaces are shown for various zones (e.g., first zone has a thermostat with a 2-wire connection), the interfaces could be permuted relative to the zones (e.g., first zone could have thermostat with a wireless connection) and other interfaces could also be used

During operation, temperature control elements **828** within the different zones **816***a*-**816***c* are configured to provide calls for heat to the controller **810**. The monitoring element **812** is configured monitor calls for heat from the different zones **816***a*-**816***c*.

In some embodiments, the monitoring element **812** is configured to collectively monitor the calls for heat from the different zones **816***a*-**816***c* in a manner that determines a prevalence of calls for heat from the facility as a whole. In such embodiments, the monitoring element **812** is configured to generate an adjustment signal that turns off the boiler **802** if a collective number of calls for heat is less than the threshold value. For example, in one example, wherein the thresh-

old value is 4, over a monitoring window 2 calls for heat are received from **828***a*, 1 calls for heat are received from **828***b*, 3 calls for heat are received from **828***c*. A monitoring element **812** configured to collectively monitor the calls for heat will determine a total number of calls for heat of 6 calls for heat over a monitoring window. Since the 6 calls for heat are greater than a threshold value the monitoring element will not turn off the boiler **802**.

In other embodiments, the monitoring element **812** is configured to separately monitor the calls for heat from the different zones **816***a*-**816***c* in a manner that determines a prevalence of calls for heat from different zones. In such embodiments, if a zone sends a call for heat (e.g., the dishwasher is in use or radiative heat is needed), the controller **810** identifies the zone or zones from which the call for heat originates. The monitoring element detects such calls for heat and generates an adjustment signal that turns off the boiler **802** if the number of calls for heat over a time period is less than a threshold value for each of the separate zones.

For example, in one example, wherein the threshold value is 4, over a monitoring window 2 calls for heat are received from **828***a*, 1 calls for heat are received from **828***b*, 3 calls for heat are received from **828***c*. A monitoring element **812** configured to separately monitor the calls for heat will determine a 2, 1, and 3 calls for heat over a monitoring window. Since neither 2, 1, or 3 calls for heat are greater than a threshold value the boiler **802** is turned off.

Although examples have been described above in the context of a temperature regulation system having a storage tank that stores a medium (e.g., a hot water tank), it will be appreciated the concepts described herein are also applicable to "tankless" water heaters. In tankless water heaters, water or some other medium is quickly heated at a manifold as the water is flowing to a zone. Other variations are also possible.

It will be appreciated that equivalent alterations and/or modifications may occur to those skilled in the art based upon a reading and/or understanding of the specification and annexed drawings. The disclosure herein includes all such modifications and alterations and is generally not intended to be limited thereby. For example, although the figures provided herein, are illustrated and described to have a particular doping type, it will be appreciated that alternative doping types may be utilized as will be appreciated by one of ordinary skill in the art.

In addition, while a particular feature or aspect may have been disclosed with respect to only one of several implementations, such feature or aspect may be combined with one or more other features and/or aspects of other implementations as may be desired. Furthermore, to the extent that the terms "includes", "having", "has", "with", and/or variants thereof are used herein, such terms are intended to be inclusive in meaning—like "comprising." Also, "exemplary" is merely meant to mean an example, rather than the best. It is also to be appreciated that features, layers and/or elements depicted herein are illustrated with particular dimensions and/or orientations relative to one another for purposes of simplicity and ease of understanding, and that the actual dimensions and/or orientations may differ substantially from that illustrated herein.

What is claimed is:

1. A boiler system, comprising:

a temperature control element configured to provide calls for heat when a temperature within a facility is below a setting value;

a boiler comprising a medium, which during operation is regulated to a temperature between a low limit and a high limit;

a medium heating element configured to raise the temperature of the medium upon receiving the calls for heat and to allow the temperature of the medium to lower when the calls for heat are concluded; and

a monitoring element configured to monitor the calls for heat provided to the boiler, to determine a prevalence of the calls for heat over a monitoring window, and to selectively adjust the low limit based upon the prevalence of the calls for heat.

2. The boiler system of claim **1**, wherein the prevalence of the calls for heat comprises a total number of calls for heat over the monitoring window.

3. The boiler system of claim **2**, wherein if the total number of calls for heat over the monitoring window is less than a threshold value the monitoring element is configured to generate a control signal that turns the boiler off.

4. The boiler system of claim **3**, wherein the monitoring element is configured to adjust the size of the threshold value, so as to vary how quickly the boiler is turned off.

5. The boiler system of claim **3**, wherein the threshold value has a non-zero value.

6. The boiler system of claim **3**, wherein the high limit has a value that is independent of a difference between the total number of calls for heat and the threshold value.

7. The boiler system of claim **1**, wherein the prevalence of the calls for heat comprises a total time in which calls for heat are made over the monitoring window.

8. The boiler system of claim **1**, wherein the boiler comprises:

a storage tank configured to store the medium;

a temperature control element configured to generate the calls for heat;

a controller having an input interface configured to receive the calls for heat from the temperature control element and an adjustment signal from the monitoring element, and an output interface configured to provide a control signal in response to the received signals; and

wherein the medium heating element is configured to receive the control signal from the controller.

9. The boiler system of claim **8**, wherein the monitoring element is configured to indirectly detect the calls for heat by monitoring a temperature of the medium within the storage tank.

10. The boiler system of claim **1**, wherein the monitoring element is configured to adjust the size of the monitoring window, so as to vary how quickly the boiler is turned off.

11. A boiler system, comprising:

a temperature control element configured to provide a call for heat when a temperature within a facility is below a setting value;

a controller configured to receive the call for heat from the temperature control element and to generate a control signal in response to the call for heat;

a medium heating element configured to raise a temperature of the medium in response to the call for heat;

a communication channel configured to relay a call for heat from the temperature control element to the controller; and

a monitoring element coupled to the communication channel, the monitoring element configured to monitor the calls for heat placed on the boiler, to determine a total number of calls for heat over a monitoring window, and to turn off the boiler system if the total number of calls for heat is less than a threshold value.

12. The boiler system of claim 11, wherein the monitoring element is configured to adjust a size of the monitoring window, so as to vary how quickly the boiler is turned off.

13. The boiler system of claim 11, wherein the monitoring element is configured to adjust a value of the threshold value, so as to vary how quickly the boiler is turned off.

14. The boiler system of claim 11,

wherein the facility comprises a plurality of different zones, each zone comprising a separate temperature control element configured to regulate the temperature within the zone; and

wherein the monitoring element is configured to separately monitor the calls for heat from the different zones, such that the boiler is turned off if the number of calls for heat over the monitoring window is less than the threshold value for each of the different zones.

15. The boiler system of claim 14,

wherein the facility comprises a plurality of different zones, each zone comprising a separate temperature control element configured to regulate the temperature within the zone; and

wherein the monitoring element is configured to collectively monitor the number of calls for heat from the different zones, such that the boiler is turned off if a collective number of calls for heat is less than the threshold value.

16. A method for adjusting a controller low limit (LL) based upon a prevalence of calls for heat, the method comprising:

providing a controller, the controller configured to:

receive a call for heat from a temperature control element and to generate a control signal in response to the call for heat;

turn on a boiler comprising a medium in response to the control signal, which during operation is regulated to a temperature between a low limit and a high limit;

operate a medium heating element to raise the temperature of the medium, to a temperature that is between the low limit and the high limit, upon receiving the one or more calls for heat;

allow the temperature of the medium to lower when the one or more calls for heat are concluded;

operating a monitoring element to determine a prevalence of the calls for heat over a monitoring window, and to selectively adjust the low limit based on the prevalence of calls for heat.

17. The method of claim 16, wherein the prevalence of calls for heat comprises a total number of calls for heat over the monitoring window.

18. The method of claim 17, further comprising:

turning off the boiler, if the total number of calls for heat over monitoring window is less a threshold value.

19. The method of claim 17, further comprising:

adjusting the size of the monitoring window, so as to vary how quickly the boiler is turned off.

20. The method of claim 16, wherein the prevalence of calls for heat comprises a total time in which the calls for heat are made over the monitoring window.

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